Trajectory Analysis Handbook

National Oceanic and Atmospheric Administration • NOAA Ocean Service

Office of Response and Restoration • Hazardous Materials Response Division

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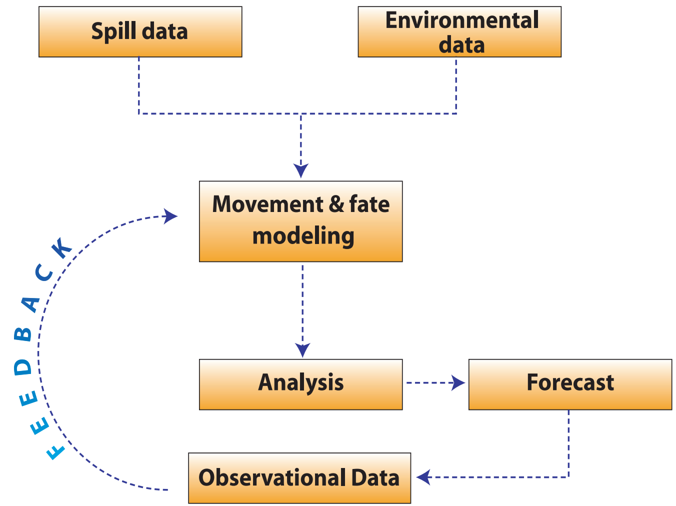
NOAA's Hazardous Materials Response Division provides scientific support to the Unified Command for response to spills in the marine environment. For further information, please visit our website at http://response.restoration.noaa.gov. This guide was developed with support from the U.S. Agency for International Development.

"Where will the oil go?"

This is a critical question asked by the emergency responder during an oil spill. Knowing the trajectory of the spill gives decision-makers critical guidance in deciding how best to protect resources and direct cleanup. However, it is often very difficult to predict accurately the movement and behavior of an oil spill. This is due, in part, to the interaction of many different physical processes about which information is often incomplete at the start of a response. The modeler must thus continuously update predictions with new data and explore the consequences and likelihood of other possible trajectories, a procedure called "trajectory analysis." The end product of trajectory analysis is often a map showing the forecast and probable uncertainty bounds of the slick movement.

This guide provides an overview of the physical processes that affect oil movement and behavior in the marine environment. Trajectory analysis is most often done using computer models to keep track of complex, interacting processes. Even without a model, you can estimate the time and length scale of an event using the information you'll find here. The guide can help the responder and planner understand physical processes and potential uncertainties as they incorporate trajectory analysis into the response.



Trajectory Analysis

Forecasting the movement of an oil spill is often hampered by insufficient input data, particularly in the first few hours of the release. Detailed **spill data** (location, volume lost, product type) are often sketchy and **environmental data** (wind and current observations and forecasts) are often sparse or unavailable. Nonetheless, the modeler must examine the data and attempt to understand the physics and chemistry that will likely affect the oil **movement and fate** of the particular spill .

With an understanding of the physical processes, the modeler can provide an **analysis** to the Unified Command as a forecast. If the initial **forecast** is inaccurate, which can occur due to erroneous spill data (e.g., location and amount of oil released) and/or erroneous environmental data (e.g., weather forecast) and model limitations, the modeling team reviews the new information and refines the forecast. In general, as the spill unfolds, the forecast of oil movement and fate improves because the quality and quantity of the on-scene **observational data** improves (while initial spill data becomes relatively less important).

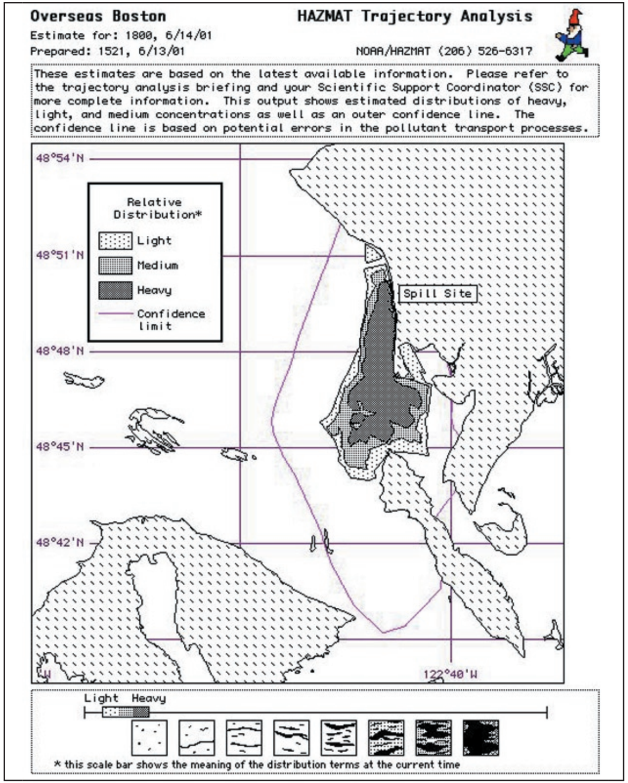
Uncertainty

Trajectory analysis should include not only the "best guess" of the oil movement and fate but also some representation of the uncertainty in the spill and environmental data used to make the forecast. The uncertainty in a trajectory forecast depends on the length and time-scale of the spill.

The following table indicates the uncertainty for input data required by most oil spill models. It should be noted that model output uncertainty is not necessarily directly proportional to model input uncertainty.

Uncertainty for input data required by most oil spill models

Category	Parameter	Uncertainty
Release details	Spill location	Low - Medium
	Time of release	Low - Medium
	Type of oil (density, viscosity)	Medium - High
	Potential spill volume	Low
	Actual spill volume	High
	Release rate	High
Oil weathering	Light refined products	Low
	Intermediate Fuel Oils (IFO 180, IFO 380, Bunker C, Fuel Oil #6)	High
	Heavily studied crude oils (Prudhoe Bay, Arabian, Ekofisk, Hibernia)	Low
	Crude oils	Medium - High
Winds	Observations	Low
	24- to 48-hour forecast	Low - Medium
	48- hour to 5-day forecast	Medium - High
	Wind drift (typically 1 to 6%)	Low
Surface currents	River	Low
	Tidal areas with current stations (unless currents are weak and variable)	Low
	Shallow-water lagoon	Low - Medium
	Shelf area (wind setup)	Medium
	Continental slope (e.g., Gulf Stream, California Current)	Low
	Abyssal Plain	High
Turbulence	Spreading	Medium
	Horizontal diffusion	Low - Medium



Sample trajectory analysis map.

Trajectory Analysis

Ideally, the trajectory is displayed in a format that is easy to understand. It should indicate both the forecast and the uncertainty. In this example, the forecast "best guess" of the oil movement is overlaid on a map of the shoreline. The forecast is presented as light, medium, and heavy contours. The scale at the bottom of the map represents the percent coverage of the surface oil within these contours. Plausible errors in the spill and environmental data were explored by the modeling team; the colored outer contour represents a 90% confidence bound. This provides an indication of the uncertainty in the forecast.